Executive Development

Requisite and Desirable Design and Construction Features of a Quint Apparatus for Miami Township

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The major design and construction features available on quint apparatus were identified primarily by manufacturers' aerial specialists and engineers. These major features were evaluated by Miami Township Division of Fire and EMS personnel and prioritized by importance. Nine highly important features and 26 moderate to highly important features were identified by the personnel. The high and moderate to high importance features were examined and those strongly impacted by the Division's response model and jurisdiction characteristics identified. Features of low importance were also identified by the personnel. The identification of these features will allow the Division ladder work group to effectively direct their energy while specifying a new apparatus for the Township.

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Introduction

The Miami Township Division of Fire and EMS is in the process of replacing its only aerial apparatus. The problem is that the Division lacks an understanding of major aerial design and construction features available in the current market place; lacks knowledge on how those features can impact the ability of an apparatus purchased to meet the needs of the Division; and lacks any information on what the personnel believe are the most important factors to consider when specifying the apparatus. Specifying and purchasing an aerial with out an understanding of these factors would likely result in a purchase that fails to meet the needs of the Township, suffers from poor user acceptance, and a loss of credibility with the staff of the Division and the Board of Trustees.

The purpose of this research is to identify the requisite and desired design and construction features of an aerial apparatus to be purchased by the Miami Township Division of Fire and EMS utilizing the descriptive research method. Through the use of personal observations, interviews, and opinion surveys, answers to four research questions below will be formulated.

1. What are the major design and construction options and features available on aerial apparatus in the market place today?

2. What tasks does the division of Fire and EMS expect the apparatus to accomplish?

3. Does the operational profile and theatre of the jurisdiction dictate the mandatory inclusion of any of the identified features?

4. What major design and construction features do the career staff of the Division feel are most important in the selection and specification of a new apparatus?

Background and Significance

Miami Township Division of Fire and EMS is currently a full service, combination fire department that provides fire, emergency medical, and fire prevention services to approximately 25,000 residents and 600 core businesses. The Township, located immediately south of Dayton, OH is the retail hub of the county, accounting for approximately 50% of the sales tax revenue generated in the county annually. In addition, Miami Township is home to the regional headquarters of Met Life, and National City Mortgage. It is also home to the corporate headquarters of LexisNexis, a major online information provider, and Isotec, a firm that manufactures isotope enriched specialty chemicals and several local or regional manufacturers and businesses. During peak retail seasons, the daytime population of the Township swells to an estimated 60,000+. Additionally, the Township is currently home to two large Christian schools, several nursing homes and assisted living centers, and many hotels, and a sea of apartments and condominiums.

The Division currently responds to approximately 3500 requests for service from four fire stations annually. Three stations are staffed around the clock daily, while a fourth is operated primarily as a paid-on-call station but staffed as personnel strength allows. The Division operates nine frontline pieces of equipment that include three engines, one aerial, three frontline medic units, a medium duty rescue, and a command vehicle.

The Division’s current aerial, purchased in 1989, is a 1989 Simon-Duplex-LTI aerial apparatus with a 75 ft. straight ladder. At the time the piece was purchased, the Division was primarily a paid on call/volunteer organization that responded to both EMS and Fire emergencies. The career personnel at the time were primarily responsible for staffing the

Division’s ambulances. These ambulances, staffed by two staff members, responded to emergency medical calls generally as the only apparatus dispatched.

These same personnel also served as drivers and anchor members for fire apparatus response when they were available. In those cases, the career members would provide part of the staff responding on an engine company and wait for paid on call personnel to arrive to fill complete the crew before leaving for an alarm. Generally, the first apparatus to leave the main station was an engine unless a need for the ladder had been identified.

Through the 1990s, the Division’s requests for service increased. Additional career and part-time employees were added to the ranks to handle the additional call load. However, until 2002, the aerial apparatus was relegated to sitting idle unless specifically requested or staffed by second wave paid on call personnel. In 2002, the Division re-examined its response profile. This re-examination resulted in a response model paradigm shift that significantly impacted how the aerial was utilized by the Division.

Specifically, two major changes in the response model were invoked. The first change was a move to make the aerial ladder the first due piece of apparatus coming from the main station. Several factors lead to the implementation of the change. The administration noted that the first due alarm district of the main station was heavily populated with commercial properties including hotels, a large regional mall, countless small businesses, and large multi-story apartment and condominium complexes. Standard of care dictates that response to fires or potential fires in these structures include a first due aerial piece. The Division believed that the need for aerial response could be met by the use of its only aerial or the inclusion of automatic aid from neighboring communities. An anecdotal examination of the response times, mutual aid apparatus availability, and response frequency indicated a need for the Division to respond its own aerial device.

The Division was unable to develop a staff reallocation plan that would allow it to staff a ladder crew as well as an engine crew out of the main station. Additionally, it found operations that required crews to jump between apparatus depending on the type and location of the call to be unworkable. The Division also lacked the financial ability to add staff. As a result, the Division moved to run the aerial device as a piece of first due equipment on all calls for service. This necessitated that the aerial be capable of performing the basic functions of both an engine and an aerial. Fortunately the current piece of equipment was capable of meeting that demand. A piece of fire apparatus that can serve as either a traditional engine or an aerial is typically referred to as a *quint.* It takes its name from the fact it possesses five key fire fighting elements: a water tank, hose body, pump, preconnected hose, and an aerial ladder. (Loeb, 2001)

The second major change in the Divisions response model was the addition of first due fire companies on requests for emergency medical service (EMS). Several factors precipitated this change. First, the Division noted that during life threatening medical emergencies, two EMS providers were insufficient to deliver care to the critical patient. The Divisions EMS units are authorized under local protocols to intervene aggressively while treating cardiac and major trauma patients. The authorized interventions are often identical to those performed in local emergency rooms by a team of double, triple, or even quadruple the staff. By dispatching a fire apparatus with the EMS unit, the Division was able to increase the number of EMS trained responders on scene to care for the patient. This increased number of personnel also allowed for better care to be given to the friends and loved ones of patients. The Division, like all EMS providers, has also recognized the problems associated with lifting, moving, and transporting more obese patients. There has been a widely reported increase in obesity levels in the United States and the Department of Health and Human Services Centers for Disease Control and Prevention (CDC) (2001) reported that the percentage of Ohio adults that qualify as obese rose from 14.9% to 21.8% between 1991 and 2001. That equated to a 46% increase in the obese population. This increase in obesity places responders responsible for lifting in moving patients at greater risk for injury. The Division concluded that supporting EMS unit response with fire companies would also provide additional lifting capabilities on scene.

Since 2002, the Division has utilized the aerial as a quint responding from its main station. After more than 16 years of service to the Division, this aerial apparatus is now slated for replacement. The Township Board of Trustees has authorized funds for the replacement and has directed the Division to prepare specifications for a replacement apparatus. Unfortunately, the Division lacks the fundamental knowledge base needed to specify this type of apparatus.

While a few of the Division's members were members at the time the current aerial was purchased, none of the current staff members were involved in the specification or purchase of the apparatus. No active Division member has experience from outside the Division specifying an aerial apparatus. Furthermore, very few Division members have any experience in specifying or purchasing apparatus because the function was primarily done by senior staffs that have all left the Division.

The replacement apparatus will continue to serve as a first due quint responding form our main station. As the busiest apparatus in the Division, it will play a key role in the operation of the Division. As such, specifying and purchasing a poorly specified apparatus could be both fiscally and operationally disastrous for the Division. In order to avoid such a situation, a research project was developed to identify requisite and most desirable features of such an apparatus in order to best serve the residents and guests of Miami Township.

Additionally, this project has the potential to reduce the life loss from fire of the three target audiences identified by the National Fire Administration (USFA) operational objectives. (USFA National Fire Academy [NFA], 2004) Those three at risk populations include those 14 and under, those 65 and older, and fire fighters and the risk of life loss will be limited by the proper selection and use of fire apparatus designed to best support rescue and suppression in Miami Township. The Township is home to a significant number of government subsidized housing units. These units are populated with financially disadvantaged families, many of whom have children 14 and under. Appropriate apparatus will help ensure a quality response to their needs. The Township is home to five major assisted living or nursing care facilities and several mature neighborhoods where the majority of residents are age 65 or older. Appropriate apparatus will help ensure a quality response to their needs. The Township is also behind a major push to develop and implement strong automatic mutual aid responses within the region and frequently provides rapid intervention teams and automatic aid companies to surrounding communities, thereby limiting the potential loss of fire fighter lives.

Finally, the project relates to the National Fire Academy's Executive Development Course in the following manner. First it is an applied research project. Applied research projects are a focus of the course and a cornerstone of the Executive Fire Officer Program. Second, the research is designed to help ensure the apparatus specified provides the best quality service to the residents and guests of the Township. Lastly, the project is designed to provide information to a group of front line responders who will be specifying the apparatus. This change from an organization that once specified and purchased apparatus based on a small number of administrators' preferences to one where many of the features are determined by the users of the apparatus is part of an overall cultural shift of the organization. Cultural change is also a primary focus of the Executive Development Course.

Literature Review

There is a small body of relevant literature available on the specification of fire apparatus. Examination of that literature reveals that it falls primarily into one or both of two categories. The first category of literature relates to the general specification and purchasing of fire apparatus. The second category of literature specifically addresses the specification and purchase of aerial fire apparatus. Both the general literature and aerial specific literature was examined.

General Apparatus Specification and Purchase

Several works in the recent literature address the general approach to specification and purchasing of apparatus. Craven (1997) briefly offers some brief some thoughts on procurement policy, estimated apparatus life expectancy, and acceptance testing of apparatus. Peters (1994) offered a comprehensive road map for apparatus purchasing in his text on the topic. The text offers advice on every step of the apparatus purchasing process including justifying the need for a new or replacement apparatus, basic needs assessment, types of apparatus, basic features of various apparatus, specification, bid evaluation, financing, delivery of the apparatus, training with the new apparatus, and preventive maintenance and warranty issues with the apparatus. While over a decade old, Peter's text provides solid analysis of several of the basic and special features of interest to those specifying apparatus.

Two more recent and condensed guides to specifying and purchasing apparatus are also available. (Peters & Pope, 2003; Peters 2003) These two works develop a basic 16 step approach to purchasing a fire apparatus. The 16 approach emphasizes identifying the apparatus that has the features and options that will best meet the needs of the jurisdiction. Additionally, it emphasizes incorporation of the National Fire Protection Association (NFPA) *1901 Standard for Automotive Fire Apparatus* as minimum performance and design criteria of any apparatus.

NFPA 1901 (2003) defines minimum requirements for the design and construction of an array of fire apparatus. This consensus standard covers general requirements of vehicles including chassis systems and components, crew areas, and specific features of the different types of apparatus. In addition, the standard provides for minimum roadability and serviceability.

Finally, Shand has developed a long series of articles on specifying and purchasing apparatus. The first six installments (Shand, 2002; Shand, 2003) of the “Apparatus Architect” follow a path similar to that taken by the previously mentioned authors. In this series, Shand outlines the process of developing a specification group, specifying and bidding an apparatus.

Aerial Specific Literature

One article in the recent literature specifically addresses the issue of specifying and purchasing an aerial apparatus. In that article, Domangue (2004) lays out a 12 step program to buying an aerial. The process relies on performing a basic needs assessment and characterization of the proposed apparatus’ operating environment. Domangue draws a distinction between many of the general apparatus specification literature by specifically addressing aerial a few commonly considered aerial specific equipment and considerations such as overall size, weight, and height requirements. Additionally Domague briefly addresses the various types of aerial devices that are available. Domague provides a brief overview of aerial ladders, elevating platforms, and water towers.

In Peters' text (1994), a more thorough discussion of the types of aerials available and their advantages and disadvantages is provided. Peters emphasizes selecting the apparatus appropriate for the jurisdiction. Additionally, Peters' article "Aerial, Platform, or Quint? That is the Question!" (2003) focuses on the fundamental operational advantages and disadvantages of each type of apparatus. Similarly, Cavette (2001) compares and contrasts ladder and platform apparatus in his work. One article chronicles the St. Louis Fire Department's design of their second generation quints. (Gerner, Riter & Schaper, 2001) In 1987, St. Louis became the first department to establish the *total quint concept* when they placed 30 quints into service. Over the subsequent 12 years, the organization learned a great deal about how these apparatus functioned in the filed and as a result, the department altered the design criteria for their next generation fleet. The article focuses on developing an ergonomically friendly, durable, and fundamentally solid apparatus with few unessential items on the apparatus.

Shand and Wilbur (2003, 2004, 2005) tailored Shand's earlier work on purchasing and specification of apparatus specifically to aerial devices in another series of their Apparatus Architect articles. This series of articles again begins with the basics, asking a series of straight forward questions. How long do you expect to run this apparatus? What do you need? What does the jurisdiction demand of the apparatus? Will it fit in the station? In part 17, Shand and Wilbur devote an entire article to addressing the advantages and disadvantages of mid-mounted and rear mounted aerial devices. This discussion includes a straight forward analysis of how the choice affects maneuverability and fireground operations. Part 21 closely examines the impact of equipment that will be placed on the apparatus on the requirements of the apparatus itself. Additionally, Shand and Wilbur examine how the compartmentation will affect the ergonomics of equipment use.

Craven (1998) examined a number reports of a great number of aerial ladder failures. His examination revealed several trends. First Craven notes that failures are typically caused by operator error, manufacturing defects, inadequate maintenance, and inappropriate repair. He also notes that only one post 1991 aerial failure has been recorded, and that the failure was a result of a maintenance problem. Post 1991 aerials have been designed to meet the NFPA 1901 standard and have seemingly nearly eliminated aerial failures in the field. Craven points to the initial load rating requirements put in the initial edition of the standard as the primary factor leading to this change. Since that first edition, many manufacturers have designed ladder systems that far exceed the minimum standards, resulting in the noted near elimination of failures. Finally, one of Craven's most interesting findings involved the ladder construction material. Craven noted that ladders constructed of aluminum had considerably fewer failures than those made of steel. As a result he concluded that aluminum was the preferred material of construction. However, in a recent phone conversation with Craven, he relayed that the importance of the aerial construction material was minimized in the post 1991 apparatus.

Literature Summary

Several authors have proposed specification and purchasing processes that are rooted in needs analysis, jurisdictional assessment, and hands on evaluation of apparatus. Only a few sources offer tailored information on aerial specific issues. Of those that offer aerial information, the largest focus is on overall height, weight, length, and position of mount. Additionally, there is a reasonably sized body of information on the advantages and disadvantages of each type of aerial device. Clearly many of these issues are relevant to the specification and purchase of an aerial in Miami Township, there appears to be very little information on what types of design features differentiate between ladder systems of various manufacturers. Additionally, a there have been advances in chassis and safety features that are not identified in the body of work.

Procedures

Selection of an Apparatus Replacement Work Group

This applied research project is designed to provide information to a work group currently charged with developing specifications for the purchase of a new quint apparatus for the Division. The work group is comprised of one senior staff member assigned by the Fire Chief, and four additional line personnel. The senior staff member assigned to the project by the Fire Chief was the Deputy Chief of Operations and serves as a facilitator and coordinator for the group.

The remaining four members of the working group were selected from a list of those who responded to a department wide request for members interested in the project. Interested members were evaluated by the Deputy Chief of Operations and the president of the bargaining unit. Members were selected in order to achieve maximum variation in years of service, platoon assignment, and representation of the bargaining unit on health and safety issues. Candidates were agreed upon and appointed to the working group.

Identification of Major Quint Apparatus Features

A list of design and construction features available in the current market place was assembled using three specific inputs. First, the working group selected a set of manufacturers based on the group's initial interest in the products and availability of local vendors. The working group selected six manufacturers of interest: American LaFrance; Crimson Fire (Luverne, Quality); E-One, Pierce Manufacturing; Seagrave Fire Apparatus, LLC; Rosenbauer (Metz Aerials, General, Central States, RK Aerial). Contact was made with each of the apparatus manufacturers directly and an aerial specialist or engineer contacted. Each specialist was first contacted and asked if they were willing to participate in the project. All agreed to participate. Then each specialist was contacted through e-mail and asked to provide input on what they felt were the top 10 most important design and construction features that should be considered when purchasing an aerial apparatus. The raw responses from each specialist were gathered and distilled by the principle researcher and placed into a working list of features.

Second, after two months of meeting and evaluating manufacturer literature, web sites, and available independent literature, the work group was brought together for a brainstorming session. The work group was charged with coming up with a comprehensive list of most important design and construction features. Items developed during that brainstorm that were not already present in the distilled manufacturers list were added to the master list.

Finally, input from the general membership of the Division has been welcomed. Many members not on the working group have attended meetings of the work group, presentations from vendors, and demonstrations from vendors. Any important design and construction features identified by these members that were not already present in the distilled manufacturers list were also added to the master list.

Identification of the Most Important Quint Apparatus Features

Items on the master list of major quint features were then evaluated for relative importance by a focus group of staff. The focus group included the four working group members, the Division's career Lieutenants, and the Division's chief officer staff that held an active status the month of April and all members of the focus group participated in the evaluation. The focus group evaluated each of the previously identified major features contained in the Aerial Features Survey contained in Appendix B. Each of the features was rated on its relative importance in the specification of a new apparatus for Division and the results tabulated.

Expected Use

The Division's senior staff is unified in their belief that the current response model of the Division is the most effective use of personnel and apparatus for the Township. The Fire Chief's direction has been that the Division will continue to respond the Division's sole aerial apparatus as a first due quint. The primary researcher then developed a primary list of the tasks the apparatus is expected to perform.

Jurisdictional Profile

The Township's jurisdictional profile was determined primarily by the researcher's observation. Data on the number of structures three stories of more was provided by the Division's Fire Inspector. Data on severity of road grades was provided by the Montgomery County Engineer's Office after direct measurement.

Procedural Limitations

Focus Group Selection. The focus group that rated the various aerial features in the Aerial Features Survey was comprised of the ladder replacement working group, the chief officers of the Division, and the career lieutenants of the Division that were in active status in the month of April 2005. The members of the work group were selected to represent the line firefighters of the Division using the criteria mentioned above. While it would initially seam more favorable to include all members of the Division, it is unrealistic to expect the entire Division to dedicate the time and effort to become knowledgeable in the technical aspects of this apparatus specification. Therefore, this research focuses on the members of the Division that have a level of technical understanding and are capable of evaluating the features considered.

The assumption is that those members that are believed to have a fundamental knowledge level in the area would represent those who do not in the process.

Manufacturers List. The manufacturers selected to participate in the process were selected based on the work group's interest and opinion. The list of manufacturers is strictly those the group was interested in and does not account for other manufacturers. It is possible that inclusion of additional manufacturers could have resulted in additional features being included in the process.

Results

Major Design & Construction Features

One question this research project was intended to answer was what major design and construction options and features available on aerial apparatus in the market place today? Through the process described above, a list of 55 major construction and design features was obtained from aerial specialist, Miami Township Division of Fire and EMS ladder work group members, and the general population of the Division. These features were distilled from the raw data input as a short identification tags, each with a brief description accompanying it. The features were then grouped into five major categories: power plant and drive train, chassis, pump, ladder, and safety/other. (See tables C1 through C5 contained in Appendix C)

Examination of the features identified in the tables contained in Appendix C reveals majority of the design and construction features identified in the process were indeed features that the literature review either specifically identified or would be arrived at from a review of the literature. However, there were several noteworthy features that were not identified in the literature.

In the power plant and drive train category, multiplexing of the electrical system was identified and the availability and inclusion of rear disc brake capability were identified as major design and construction features. In the chassis category, the study identified cab ingress and egress ergonomics as a major design and construction feature. In the safety and other category, the inclusion of crash tested cab designs and side curtain air bag systems were identified as major design and construction features. Finally, in the ladder category the results identified ladder construction stock shape, ladder climbing width, ladder rail height, ladder lift capability, ladder rung characteristics, and grease free ladder designs as major design and construction features that were not anticipated prior to assembling the results.

Important Design & Construction Features

In order to assess the relative importance of each feature identified in table C1 through C5, the features and short descriptors were placed in to a survey and distributed to the identified group of evaluators. The evaluators were asked to indicate the relative importance of each feature to the specification of a new apparatus for the Division using the scale shown in Table C6. Examination of the overall results contained in Table C7 revealed that of the 55 features identified, the 9 identified in Table 1 were selected by seven or more (> 63%) of the respondents as highly important to the specification of a new apparatus. These 9 items are clearly the most important to the respondents and should be given the greatest attention during the specification and purchasing process.

None of the features evaluated were clearly identified by seven or more respondents as items that were of no importance in the specification of the apparatus. However, examination of the data revealed that 10 of 55 features evaluated were rated as of no or low importance by at least seven of the 11 respondents. The features, shown in Table 2, are clearly the least important features of those evaluated by the respondents. Of the 36 items that were not identified as either of high importance or little importance to the respondents, 26 had seven or more respondents indicate that they were of high or moderate importance. These items, of moderate to high importance to the evaluators are contained in Table 3. The remaining features were shown to be of low to moderate importance to the respondents. A summary of the number of features rated as high importance, moderate to high, low to moderate, and low importance is shown in Table 4.

Table 1

Features of High Importance

Feature	Respondents Indicating High Importance
Engine size	9
Power steering type & manufacturer	9
Overall Maneuverability	8
Compartment space & configuration	8
Hose load capacity	8
Ladder reach	8
Rear disc brakes	7
Overall travel height	7
Ladder warranty	7

Table 2

Features of Low Importance

Feature	Respondents Indicating Low or No Importance
Ladder construction stock shape	10
Outrigger pins	10
Ladder rung characteristics	9
Ladder deflection when loaded	9
Ladder tip controls	8
Hose loading with out raising aerial	8
Ladder lift capacity	8
Stainless steel plumbing	7
Platform	7
Ladder waterway outlet	7

Table 3

Features of Moderate Importance

Feature	Respondents Indicating High or Moderate Importance
Cab ingress/egress ergonomics	11
Ladder tip load rating	11
Smoothness of ladder operation	11
Corrosion resistance	11

Outrigger deployment speed	11
Outrigger capability on uneven slope	11
Overall chassis weight	10
Departure angle	10
Cab crew space	10
Water tank capacity	10
Pump Capacity	10
Mount location	10
Deployment speed	10
Tip over safety factor	10
Preconnected hose lines	9
Pump panel layout	9
Crash testing	9
Ladder tip load safety factor	9
Torque box construction	9
Turntable access	9
Outrigger spread	9
Side curtain air bags	8
Ladder assembly weight	8
Load distribution chart	8
Load sensing	8
Ladder environmental evaluation	7

Table 4

Features

Rating	No. of Features
High importance	9
Moderate to high importance	26
Low to moderate importance	10
No to low importance	10

Division Expectations

In order to determine the Division's expectations of the aerial apparatus to be purchased, the Division's response profile was first considered. As mentioned earlier in this work, the Division currently operates its aerial from the main station where it runs as a first due quint. Discussions between the command staff and the Fire Chief have indicated that the Division has no current plan to change this practice and anticipates continuing the practice through the foreseeable future.

The current apparatus responds to roughly 2500 calls for service annually. Of those calls, approximately 1500 (60%) are for emergency medical emergencies. The remaining requests for service are responses to automatic fire alarms, vehicle rescue, and special service calls. The Division has seen a steady increase in the requests for service of this apparatus and expects that trend to continue and possibly accelerate with the approved addition of more commercial and retail space to the primary response area of the apparatus. The approved addition of response generators includes a hotel district at a new interstate interchange, a regional mall expansion, addition of a Super Wal Mart, conversion of an existing Wal Mart to a Sam's Club, and an airport expansion and business development district. The Division expects the apparatus to serve the Division for 15 years.

While serving, the Division expects the apparatus to serve as a first out quint. In that capacity, it will need to meet the minimum expectation placed on the engines of the current fleet. These engines are expected to have preconnected hose lines and a water tank volume capable of sustaining initial attack independently for 3 to 5 minutes. It will be required to pump at least 1500 gpm. The apparatus will be required to have a compliment of large diameter hose meeting the current NFPA 1901 minimum standards. It will also be required to carry a full compliment of hand tools, power tools, hose appliances, a ventilation fan, portable lighting and a power generator. It will need to comfortably transport up to five fire fighters in a noise limited and temperature controlled environment. In addition, the apparatus must be able to function as the Division's aerial apparatus. It needs to have a full compliment of ladders as defined for a quint in NFPA 1901, the requisite hand tools, and the requisite power tools. As an aerial, the apparatus must be easily and rapidly deployed for fire fighting and rescue operation. Additionally it is essential that the maneuverability of the apparatus improve or remain consistent with the current apparatus.

Dictated Features

Examining the features identified in Table 1 as highly important would indicate that decisions on 5 of the 9 features be heavily impacted by the operational profile and theatre. First, the engine size specified will be impacted. Additionally, several features in the moderate to highly important category will also be impacted by the profile and theatre.

As mentioned earlier, the Division expects the quint apparatus to function in a rescue capacity. As such, speed of set up will be critical. Tip load capacity will also be critical to rescue capability. Clearly a ladder rated for 250 lbs. of load at the tip will be inadequate to hold a firefighter and victim. Additionally, it is likely that an aerial used for rescue or emergency egress will need to accommodate a minimum of two personnel and in some instances more.

While NFPA 1901 (2003) requires that apparatus maintain speed on a 6% grade, the Township has several major roads that have grades much steeper than that. A query of the Montgomery County Engineers' office revealed that grade of four major roads in the jurisdiction ranged from 6.8% to 13.7%. The specification for the apparatus must address this issue when specifying the engine size as it relates to its ability to move the overall weight of the apparatus. Additionally, the specification will need to closely examine the ladder deployment capabilities on roads with larger than average grades. As a result of the terrain, there are several areas where angle of departure will be critical to pulling into apartment and condominium access areas.

Ladder reach is similarly dictated by the jurisdiction. ISO requirements for the aerial apparatus in this alarm area require that ladder companies have aerial devices that are capable of reaching the roof of the tallest building in the response area or a minimum of 100 feet in length, which ever is less. There are currently several structures within the response area that require a ladder reach in excess of 80 feet based on their height and set back distances.

Maneuverability will also be dictated by the jurisdiction's response area. While the Township's main thoroughfares and feeder streets are fairly well sized, the Township in general, and the first due area of this apparatus in particular has over one dozen large multi-family apartment and condominium complexes. Many of these complexes have narrow access drives and vehicle parking that obstructs fire apparatus routinely. As a result, the new apparatus will need to be as maneuverable as possible. Additionally, because maneuverability is significantly impacted by mounting an aerial device on the rear of the apparatus rather than the middle of the apparatus, it is likely the maneuverability requirements will dictate a rear mount apparatus.

Overall travel height of the apparatus will be affected by the operational theatre as well. There are several places in the jurisdiction where low hanging utility lines are present. Additionally, apparatus with travel heights greater than 10 ft. 11 in. will require modification of the fire station to accommodate the apparatus.

Finally, the proposed quint will serve in the central business district of the Township. Operations in this district require response through some of the most congested road ways and intersections in the State of Ohio. These areas have been proven to require heavy and frequent braking. These conditions favor the inclusion of a rear disc brake system on the apparatus.

The current operational profile of the Division requires that engine companies have 1500 gpm pumps. It is reasonable to expect that the new apparatus will have no less pump capacity. While in some areas of the jurisdiction, particularly outside the first due district of the apparatus to be purchased, there are some water supply issues. In these areas, hydrant flows less than a 1000 gpm may be experiences. There are several areas where hydrant flows of 2000 gpm can easily be achieved in the first due area for this apparatus. Therefore pump capacity will not typically be limited by the water supply.

Discussion

There were a number of articles in the literature that described processes for developing specifications and purchasing requirements for apparatus. The Miami Township Division of Fire and EMS has started down a path toward purchase similar to those suggested by Peters and Pope (2003) and Domangue (2004). Gathering information and examining the first due area the apparatus will serve are critical to making an effective purchase as noted several places in the literature. (Domague, 2004; Peters, 2003; Shand & Wilbur, 2003) The majority of features identified during the initial stage of this project were suggested in the literature review. For example Peters (1994) suggest that organizations closely examine their response areas to assess grade for proper engine sizing. Shand and Wilbur (2003) note the effect of grade on ladder operations. Similarly, ladder reach (Peters, 2003) and mount location (Shand & Wilbur, 2004) are also covered by a number of authors.

While much of this effort supports the work of these other authors, it is notable that this study identified several items of importance that were not spotlighted in the literature. For example, the inclusion of rear disc brakes was included on the initial list of major features and was later identified as having a high importance in the specification process. Examination of the literature in the heavy trucking industry reveals that rear disc brakes for trucks are viewed as a safety feature and one study shows that rear disc brakes on heavy trucks can cut stopping distances at 60 mph by over 20%. (Winsor, 2004) Winsor also notes that disc brakes have clear advantages at high speeds and during wet road operations. Personal conversations with maintenance personnel at the Miami Township garage indicate that mechanics charged with maintaining our fleet believe that we will realize maintenance savings and decreased downtime in addition to the safety factor rear disc brakes will provide.

Furthermore, while some commonly accepted safety features like anti-lock brakes are described in the literature, there was little mention of the availability of crash tested cab designs or side roll over protection. While several manufacturers list that they crash test some cab designs, there is very little emphasis in the literature on the topic for the end user. Considering the fact the U.S. Fire Administration has placed a high priority on crash testing and modeling in crash tests in emergency vehicles it would be logical that organizations are interested in crash tested designs and the standards to which they are crash tested. . (U.S. Fire Administration, 2003)

This work also identified roll over protection as a moderate to high important consideration when specifying an apparatus. Tilyou (2004) describes roll over protection (including side air curtains) and makes a convincing case that they decrease severity the injuries for those involved in roll over crashes. Tilyou notes that nearly all fire fighter fire truck fatalities between 1994 and 1996 involved a fire truck roll over. This technology, available only for nearly two years has not been emphasized in the literature.

Lastly, it should be noted that very little information about the advantages of independent front suspension systems and air ride suspension systems in fire apparatus is available in fire service publications. However, literature can be found through manufacturers and trade publications in other industries such as the construction industry. (Ludorf, 2005) The literature suggests that these suspension systems can greatly impact safety, handling, maintenance costs, and maneuverability.

In summary, this research developed a list of major design and construction features available in today's aerial apparatus that included items not previously noted in the literature. Additionally, this list of available design and construction features was evaluated by the Division's personnel and features prioritized by importance. The prioritization identified several features identified in the literature as important, but also some that were not noted in other works. This will allow the Division to research these features that would have otherwise went unexamined and make information based decisions on their need and inclusion. This work also was able to identify several operational and jurisdictional characteristics that will play key roles in determining the proper specifications as they relate to several of the items identified as highly important or moderately to highly important to the Division's personnel. This should provide a strong foundation for the ladder work group to build upon during their specification and purchasing process.

Recommendations

The preliminary results of this work have already been shared with members of the ladder working group. Some have noted that a number of the priority design and construction features are dictated by safety concerns, long term maintenance concerns, or jurisdictional characteristics. However, there are a number that are very dependent on user preference. As a result, one recommendation is that the work group investigates issues such as the numbers and types of preconnected hose lines, pump panel layout, and turntable access are significantly impacted by department by polling the department as a whole.

Additionally, many of the important features identified in the process are affected by other features of various importances to the group. The work group needs to examine the prioritized lists and determine what features affect those of moderate to high and high importance and decide where compromises between the competing features can be reached. These trade offs will be vitally important considering the use of the apparatus as a first due apparatus and the requirement that it be adequate at performing as an engine and as an aerial device.

Finally, it is recommended that the Division's work group take the list of prioritized features and couple that with their recent experiences with demo apparatus to forge a specification for purchase. The work group has closely examined several manufacturers demo apparatus and put them through the paces in jurisdiction. The group has examined aerial set up, maneuverability and handling in trouble areas of the district, cab features, and ease of use. This information coupled with the prioritized list of factors should provide and excellent guide to specification.

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Appendix A: Manufacturer Questionnaire

Recipient Name:

I appreciate you getting back to me.

I am working on a project for a National Fire Academy class that also impacts my home department. My department is in the process of specifying a new ladder/quint to replace a piece that is running the line currently. Approach wise, I want our folks to concentrate on function rather than manufacturer, paint shine, or gadgets we may or may not need.

In other words, I want our crews first to identify what major construction and design features are necessary for us to do the work we anticipate doing with the apparatus. Second, I want them to identify what it is that they most desire in this apparatus, the things that are not MUST haves, but rather should make working with the rig more efficient, ergonomic, etc. When we have that in hand, we can take a look at what is out there and see what best matches our identified needs and the prioritized desires.

To that end, I am compiling a list of the most important/significant design and construction features we should be looking at via experts like your self. So, if you would, please answer the following question for me:

In your opinion, what are the top 10 design and construction features that should be considered when buying an aerial apparatus? If you could briefly elaborate on each, that would be great.

As an example, one may say that crew compartment air bags are most important because of the prevalence of apparatus accidents in the US and the fire fighter fatality and injuries that result from them. Or that the jack/stabilizer design that has the narrowest working width is important.

Thanks!
Glenn P. Jirka
Deputy Chief of Operations
Miami Township Division of Fire and EMS

Appendix B: Aerial Features Survey

Examine the aerial apparatus construction features or options listed in the table below. In the columns immediately to the left of each item, indicate the relative importance of each feature or option in the specification of a new apparatus for MTFD.

HI = HIGH importance: Items that will critically affect the performance of the apparatus at MTFD.
MOD = MODERATE importance: Items that will not critically affect the performance of the apparatus but may have a significant affect on the performance of the apparatus at MTFD.
LO = LOW importance: Items that will minimally affect the overall performance of the apparatus in MTFD. These items may be considered niceties or be used only in extremely rare instances.
NO = NO importance: Items that simply will not affect the overall performance of the apparatus in MTFD.

				POWER PLANT AND DRIVE TRAIN ISSUES
HI	MOD	LO	NO	ENGINE SIZE. The size (power) of the power plant supplied with the apparatus.
HI	MOD	LO	NO	POWER STEERING. The type and manufacturer of the power steering system.
HI	MOD	LO	NO	MULTIPLEXING ELECTRICAL SYSTEM. Using a conventional wiring system, each and every switch in the system requires an individual copper wire from the switch, to a relay, to the device being activated The quantity of wire and connections can be enormous, especially if several additional switches activate the same circuit. In a multiplexed system, the signal is carried along a simple twisted pair of wires called the network data bus. A system manager module then interprets the correct logic and continues the signal to the affected node, which activates the device. Multiplexing makes computer diagnostics more effective and limits the numbers of wires running through the chassis in hopes of avoiding the needle in the hay stack approach to fixing an electrical problem with the apparatus.
HI	MOD	LO	NO	REAR DISC BRAKES. Apparatus brakes are either of a drum or disc type brakes. Disc brakes are viewed as superior because of their ability to operate under heavy breaking scenarios with out “fading.” Vehicles now days come with front disc breaks because most of the breaking is done by the front breaks. Many manufacturers also offer rear disc brakes as an option. This will also increase braking ability and lengthen brake life.
HI	MOD	LO	NO	OVERALL CHASSIS WEIGHT (GVW). The overall weight of the apparatus impacts the ability of the apparatus to go over certain bridges, operate in certain areas like parking lots, and contributes to the overall wear and tear on the apparatus.
HI	MOD	LO	NO	OVERALL TRAVEL HEIGHT. The overall height of the apparatus will impact its ability to get in and out of our station, work near low power and utility lines, and pass under bridges.
HI	MOD	LO	NO	DEPARTURE ANGLE. In side view, this is the angle between the ground and a line running from a rear tire to the lowest-hanging component directly behind it, usually the rear bumper. The departure angle indicates a vehicle's ability to drive off a ramp or obstacle without damaging the rear of the vehicle.
HI	MOD	LO	NO	OVERALL CHASSIS MANEUVERABILITY –TURN RADIUS, CRAMP ANGLE, WHEELBASE. The combination of cramp angle, overall travel length, length of wheel base, and turn radius all contribute to an apparatus’ ability to maneuver through the streets of the Township.

				OTHER
HI	MOD	LO	NO	SINGLE SOURCE PROVIDER. Some manufacturers are “single source” providers. In other words, the same manufacturer builds the chassis, body, and the aerial device. The advantage is a single source for warranty and service issues.

				CHASSIS ISSUES
HI	MOD	LO	NO	CAB INGRESS/EGRESS ERGONOMICS. Crews enter/exit the apparatus thousands of times each year.
HI	MOD	LO	NO	CAB CREW SPACE. Crews will spend a significant amount of time traveling to and from emergencies and training in the cab of this apparatus.
HI	MOD	LO	NO	COMPARTMENT SPACE VOLUME AND CONFIGURATION. This apparatus will serve as a quint. As such it will be asked to carry a full compliment of engine equipment and a significant percentage of what is typically found on a ladder company. In addition it is likely to carry a basic compliment of hydraulic rescue tools.
HI	MOD	LO	NO	HOSE LOAD CAPACITY. Quint and ladder apparatus are built with various size hose beds. Most hose beds are capable of accommodating anywhere from 500 ft of 5 in diameter hose up to 1000 ft of 5 in diameter hose. Hose beds are available with single or dual shoots from the rear of the apparatus.
HI	MOD	LO	NO	HOSE LOAD WITH OUT RAISING LADDER. Some hose bed configurations allow for the packing of the rear hose bed without raising the aerial device.
HI	MOD	LO	NO	WATER TANK CAPACITY. Booster tank capacity on apparatus of this type typically ranges from 300 gals up to 500 gals and in some instances higher.
HI	MOD	LO	NO	PRECONNECTED HOSE LINES. Most apparatus of this type come with two cross lays while some come with three. In addition, most manufacturers offer the option of a bumper mounted preconnected.

				PUMP FEATURES
HI	MOD	LO	NO	PUMP CAPACITY. There are many options for pump capacity. The current standard at MTFD is a 1500 gpm pump while demo trucks on the street are often 2000 gpm.
HI	MOD	LO	NO	PUMP PANEL LAYOUT/EASE OF USE. Pump panel layouts come in an infinite number of designes but some itmes such as color coding is mandated by standards.
HI	MOD	LO	NO	STAINLESS STEEL PLUMBING. Some manufacturers offer stainless steel plumbing from the pump housing out to the discharges and preconnects.
HI	MOD	LO	NO	MANUFACTURER. Of the Division's current pumps, all but one are the same manufacturer.

				SAFETY
HI	MOD	LO	NO	CRASH TESTING. Over the past few years, some manufacturers have begun to crash test their apparatus to ensure their safety – just as auto manufacturers do. Some manufacturers do not crash test at all, some certify and crash test to European standards, and others certify and crash test to US standards.
HI	MOD	LO	NO	SIDE CURTAIN AIR BAGS. At least three manufacturers have the ability to provide the Rolltek side curtain air bag/roll over protection system that automatically deploys in the event of a roll of the apparatus. These bags are designed to offer protection to the occupants by keeping them in the cab of the apparatus.

				LADDER FEATURES
HI	MOD	LO	NO	PLATFORM. Aerial devices are typically classed as straight ladders, towers, tower-ladders, ladder-towers, and articulating boom platforms. One major distinguishing factor between a straight ladder and the other types of aerials is the platform.
HI	MOD	LO	NO	MOUNT LOCATION. Aerial devices come with the base of the device mounted over the rear of the apparatus (rear-mount) or mounted directly behind the cab (mid-mount). Each has their particular advantages and disadvantages.
HI	MOD	LO	NO	LADDER REACH. Overall ladder reach determines the heights of buildings and objects the ladder may reach. Additionally, ladders with longer reach operate with more ladder section overlap than a shorter ladder and provide a greater safety margin during lower angle use.
HI	MOD	LO	NO	LADDER COMPOSITION. [Steel vs. Aluminum] There has been a long standing debate between folks that believe aerials should be constructed of aluminum and those that believe steel is a better material. The proponents of steel point to the fact that it recovers from high heat exposures during water tower applications better than aluminum which more easily looses its chemical/physical properties and can be damaged by extend periods of heat exposure. The aluminum folks point out that aluminum reflects heat to a greater extent than steel and that aluminum ladders have better safety records than steel ladders according to an article in American Fire Journal. Composition can also effect weight and strength of the aerial device.
HI	MOD	LO	NO	LADDER CONSTRUCTION STOCK SHAPE. The main structure of the ladder can be made from solid circular or rectangular stock, tubular stock (hollow in the middle), or I-Beam materials. Each stock shape offers advantages over the other.
HI	MOD	LO	NO	LADDER TIP LOAD. Aerials are required by NFPA 1901(2003 ed.) to be capable of carrying its rated capacity on the outermost rung on the outermost fly section of the ladder with NO water flow and extend 100% in any position. Aerials are required at a minimum to have a 250 lb rating. Manufacturers also provide rated capacities based on water flowing (in any direction from the water pipe) at various angles of incline.
HI	MOD	LO	NO	LADDER TIP LOAD SAFETY FACTOR. Aerials are required to have a safety factor of 2:1 for ladder strength. Most manufacturers design and rate based on a 2:1 factor, while at least one manufacturer utilizes a safety factor of 2.5:1.

HI	MOD	LO	NO	LADDER ENVIRONMENTAL EVALUATION. Aerial devices are real devices used on the street. At least one manufacturer evaluates their tip load conditions while also taking into account icing and winds of up to 50 mph.
HI	MOD	LO	NO	LADDER TIP CONTROLS. Straight sticks may or may not come with controls mounted at the tip of the ladder that can control the ladder movement.
HI	MOD	LO	NO	LADDER CLIMBING WIDTH. Aerial ladders are required to have a minimum width of 18 inches, measured at the narrowest point on the ladder. The widest ladder available in the market place has a width of 22.75 inches.
HI	MOD	LO	NO	LADDER RAIL HEIGHT. Aerial ladders are required to have a minimum rail height of 12 inches. The ladder with the highest ladder rails in the market place has rails that are nearly 22 inches tall.
HI	MOD	LO	NO	LADDER RUNGS. Aerial ladder rungs may be round or otherwise shaped and are required to be either covered with a skid-resistant cover or have an integral skid-resistant surface. Some manufacturers believe that a coated rung is important because it offers a non-rigid surface that will cause ice to crack off during cold weather operations. Other manufacturers believe integral climbing surfaces limit the maintenance issues with replacing ladder rung covers that will be required as they age or are exposed to heat.
HI	MOD	LO	NO	LADDER DEFLECTION WHEN LOADED. When extended, ladders naturally sag or deflect Some ladder designs deflect more than others.
HI	MOD	LO	NO	DEPLOYMENT SPEED. Aerial ladders are required by NFPA 1901 (2003 ed.) to be able to go from the stored position to fully extended, rotated 90^{o}, and maximum elevation in 120 seconds or less. Times of less than 60 seconds are achievable.
HI	MOD	LO	NO	TIP OVER SAFETY FACTOR. Aerial ladders are required by NFPA 1901 (2003 ed.) to have a 1.5:1 "tip over" safety factor. This means the device will accommodate 1.5 times its rated capacity at every position with out tipping over. The requirement is decreased to a 1.33:1 factor while on a slope of 5 degrees. Some manufacturers rate their tip over safety at 1.5 even on the 5% slope.
HI	MOD	LO	NO	GREASE FREE LADDER DESIGN. Some manufacturers are moving toward aerials that require no lubrication. Rather than sections of the ladder sliding along greased wear pads, they instead roll on roller system or wear pad made of metal or nylon. Greaseless systems decrease maintenance cost and time as well as offer a generally smother extension/retraction of the device.
HI	MOD	LO	NO	LADDER ASSEMBLY WEIGHT. Various ladder designs result in different overall ladder weight. Limiting the weight of the ladder on top of the apparatus may limit the wear and tear on the chassis caused by this ladder forces pounding the chassis as it drives the road.
HI	MOD	LO	NO	TORQUE BOX CONSTRUCTION. The "torque box" is the portion of the aerial that takes the apparatus that carries the load of the ladder. The jack system is attached to this box, as is the ladder. The box functions to keep th rig from twisting and bending as you operate the aerial. Manufacturers offer torque boxes that are bolted to the frame of the truck, an integral part of the frame, or welded to the chassis rail system. [3, 4]

HI	MOD	LO	NO	SMOOTHNESS OF LADDER OPERATION. Various manufacturers have different features they use to increase the smoothness of operation of the aerial device. Some use rollers rather than wear pads for the ladder to slide on, one uses dual turntable motors to limit back lash, while others depend on hydraulic system design to limit the back lash or uneven movement of the ladder.
HI	MOD	LO	NO	LADDER WARRANTY. Aerial manufacturers offer a variety of warranties on their products. Most ladders come with 10 to 20 year structural warranties.
HI	MOD	LO	NO	CORROSION RESISTANCE. Steel rusts, aluminum oxidizes. In order to reduce corrosion, manufacturers of steel ladders must coat and protect their ladder assemblies. Manufacturers use various processes to accomplish this. Aluminum ladders do not rust or corrode to the extent steel ladders do but do oxidize.
HI	MOD	LO	NO	TURNTABLE ACCESS. The ability to ascend to the turntable from the ground and to safely step on to the turntable from the access point is important to operations. Grab rails, climbing angles, and access to the turntable are issues that need to be examined.
HI	MOD	LO	NO	BELOW GRADE OPERATION. To what extent can the ladder be deployed below grade to assist with special rescue operations. There are varying degrees of capability amongst the manufacturers.
HI	MOD	LO	NO	LOAD DISTRIBUTION CHARTS. Although tip loads are stated in increments of 250 lbs, a ladder rated at 500 lbs tip load may be able to sustain additional loading while tip loaded. Some manufacturers indicate that information on the base of the ladder near the pedestal operator.
HI	MOD	LO	NO	LADDER RESCUE ATTACHMENTS. Many manufacturers sell attachments points for rescue equipment or rescue attachments designed to be placed on the ladder.
HI	MOD	LO	NO	LADDER LIFT CAPABILITY. At least one manufacturer believes you should be able to use the ladder as a crane and offers an automated load management system that will allow the ladder to function as a crane within predefined limits.
HI	MOD	LO	NO	LADDER WATERWAY OUTLET. Manufacturers offer gated waterway outlets so that lines may be extended from the tip of the ladder.
HI	MOD	LO	NO	OUTRIGGER DEPLOYMENT SPEED. The speed of outrigger deployment varies from manufacturer to manufacturer, but all must be able to fully deploy their systems within the 90 seconds per NFPA 1901 (2003 ed.).
HI	MOD	LO	NO	OUTRIGGER PINS. Some outrigger designs require that safety pins be inserted into the outriggers during set up. This requires the operator to go around the apparatus and pin each outrigger before operation.
HI	MOD	LO	NO	OUTRIGGER SPREAD. Manufacturers have various engineering designs that provide stability to the aerial. Some outrigger systems have widths that span 18’ or better when fully extended. Others have jack spreads as small as 12’ fully spread.
HI	MOD	LO	NO	SHORT JACK CAPABILITY. Some manufacturers allow the ladder to be operated without all the out riggers being fully extended. Interlocks are installed to keep users from operating outside of the area where it can be safely operated..
HI	MOD	LO	NO	LOAD SENSING. One manufacturer uses an automatic load sensing system that will allow use on the short jack side as long as it is in with safe parameters as sensed by the load sensing system.

HI	MOD	LO	NO	OUTRIGGER CAPABILITY ON UNEVEN SLOPES. Outrigger systems are capable of operating on various degrees of slope.

Appendix C: Tables

Table C1

Power Plaint and Drive Train Features

Feature	Description
Engine size	The size (power) of the power plant supplied with the apparatus.
Power steering	The type and manufacturer of the power steering system.
Multiplexing	Using a conventional wiring system, each and every switch in the system requires an individual copper wire from the switch, to a relay, to the device being activated The quantity of wire and connections can be enormous, especially if several additional switches activate the same circuit. In a multiplexed system, the signal is carried along a simple twisted pair of wires called the network data bus. A system manager module then interprets the correct logic and continues the signal to the affected node, which activates the device. Multiplexing makes computer diagnostics more effective and limits the numbers of wires running through the chassis in hopes of avoiding the needle in the hay stack approach to fixing an electrical problem with the apparatus.
Rear disc brakes	Apparatus brakes are either of a drum or disc type brakes. Disc brakes are viewed as superior because of their ability to operate under heavy breaking scenarios with out “fading.” Vehicles now days come with front disc breaks because most of the breaking is done by the front breaks. Many manufacturers also offer rear disc

	brakes as an option. This will also increase braking ability and lengthen brake life
Overall chassis weight	The overall weight of the apparatus impacts the ability of the apparatus to go over certain bridges, operate in certain areas like parking lots, and contributes to the overall wear and tear on the apparatus.
Overall travel height	The overall height of the apparatus will impact its ability to get in and out of our station, work near low power and utility lines, and pass under bridges.
Departure angle	In side view, this is the angle between the ground and a line running from a rear tire to the lowest-hanging component directly behind it, usually the rear bumper. The departure angle indicates a vehicle's ability to drive off a ramp or obstacle without damaging the rear of the vehicle.
Overall maneuverability	TURN RADIUS, CRAMP ANGLE, WHEELBASE. The combination of cramp angle, overall travel length, length of wheel base, and turn radius all contribute to an apparatus’ ability to maneuver through the streets of the Township.

Table C2

Chassis Features

Feature	Description
Cab ingress/egress ergonomics	Crews enter/exit the apparatus thousands of times each year.
Cab crew space	Crews will spend a significant amount of time traveling to and from emergencies and training in the cab of this apparatus.
Compartment space volume & configuration	This apparatus will serve as a quint. As such it will be asked to carry a full compliment of engine equipment and a significant percentage of what is typically found on a ladder company. In addition it is likely to carry a basic compliment of hydraulic rescue tools.
Hose load capacity	Quint and ladder apparatus are built with various size hose beds. Most hose beds are capable of accommodating anywhere from 500 ft of 5 in diameter hose up to 1000 ft of 5 in diameter hose. Hose beds are available with single or dual shoots from the rear of the apparatus.
Hose load without raising ladder	Some hose bed configurations allow for the packing of the rear hose bed without raising the aerial device.
Water tank capacity	Booster tank capacity on apparatus of this type typically ranges from 300 gals up to 500 gals and in some instances higher.
Preconnected hose lines	Most apparatus of this type come with two cross lays while some come with three. In addition, most manufacturers offer the

option of a bumper mounted preconnected.

Table C3

Pump Features

Features	*Description*
Pump capacity	There are many options for pump capacity. The current standard at MTFD is a 1500 gpm pump while demo trucks on the street are often 2000 gpm.
Pump panel layout/ease of use	Pump panel layouts come in an infinite number of designes but some itmes such as color coding is mandated by standards.
Stainless steel plumbing	Some manufacturers offer stainles steel plumbing from the pump housing out to the discharges and preconnects.
Manufacturer	Of the Division's current pumps, all but one are the same manufacturer.

Table C4

Safety & Other

Features	*Description*
Crash testing	Over the past few years, some manufacturers have begun to crash test their apparatus to ensure their safety, just as auto manufacturers do. Some manufacturers do not crash test at all, some certify and crash test to European standards, and others certify and crash test to U.S. standards.
Side curtain air bags	At least three manufacturers have the ability to provide the Rolltek side curtain air bag/roll over protection system that automatically deploys in the event of a roll of the apparatus. These bags are designed to offer protection to the occupants by keeping them in the cab of the apparatus.
Single source provider	Some manufacturers are “single source” providers. In other words, the same manufacturer builds the chassis, body, and the aerial device. The advantage is a single source for warranty and service issues.

Table C5

Ladder Features

Features	*Description*
Platform	Aerial devices are typically classed as straight ladders, towers, tower-ladders, ladder-towers, and articulating boom platforms. One major distinguishing factor between a straight ladder and the other types of aerials is the platform.
Mount location	Aerial devices come with the base of the device mounted over the rear of the apparatus (rear-mount) or mounted directly behind the cab (mid-mount). Each has their particular advantages and disadvantages.
Ladder reach	Overall ladder reach determines the heights of buildings and objects the ladder may reach. Additionally, ladders with longer reach operate with more ladder section overlap than a shorter ladder and provide a greater safety margin during lower angle use.
Ladder composition	[Steel vs. Aluminum] There has been a long standing debate between folks that believe aerials should be constructed of aluminum and those that believe steel is a better material. The proponents of steel point to the fact that it recovers from high heat exposures during water tower applications better than aluminum which more easily looses its chemical/physical properties and can be damaged by extend periods of heat

	exposure. The aluminum folks point out that aluminum reflects heat to a greater extent than steel and that aluminum ladders have better safety records than steel ladders according to an article in American Fire Journal. Composition can also affect weight and strength of the aerial device.
Ladder construction stock shape	The main structure of the ladder can be made from solid circular or rectangular stock, tubular stock (hollow in the middle), or I-Beam materials. Each stock shape offers advantages over the other.
Ladder tip load	Aerials are required by NFPA 1901(2003 ed.) to be capable of carrying its rated capacity on the outermost rung on the outermost fly section of the ladder with NO water flow and extend 100% in any position. Aerials are required at a minimum to have a 250 lb rating. Manufacturers also provide rated capacities based on water flowing (in any direction from the water pipe) at various angles of incline.
Ladder tip load safety factor	Aerials are required to have a safety factor of 2:1 for ladder strength. Most manufacturers design and rate based on a 2:1 factor, while at least one manufacturer utilizes a safety factor of 2.5:1.
Ladder environmental evaluation	Aerial devices are real devices used on the street. At least one manufacturer evaluates their tip load conditions while also taking into account icing and winds of up to 50 mph.

Ladder tip controls	Straight sticks may or may not come with controls mounted at the tip of the ladder that can control the ladder movement.
Ladder climbing width	Aerial ladders are required to have a minimum width of 18 inches, measured at the narrowest point on the ladder. The widest ladder available in the market place has a width of 22.75 inches.
Ladder rail height	Aerial ladders are required to have a minimum rail height of 12 inches. The ladder with the highest ladder rails in the market place has rails that are nearly 22 inches tall.
Ladder rungs	Aerial ladder rungs may be round or otherwise shaped and are required to be either covered with a skid-resistant cover or have an integral skid-resistant surface. Some manufacturers believe that a coated rung is important because it offers a non-rigid surface that will cause ice to crack off during cold weather operations. Other manufacturers believe integral climbing surfaces limit the maintenance issues with replacing ladder rung covers that will be required as they age or are exposed to heat.
Ladder deflection	When extended, ladders naturally sag or deflect Some ladder designs deflect more than others.
Deployment speed	Aerial ladders are required by NFPA 1901 (2003 ed.) to be able to go from the stored position to fully extended, rotated 90^{o}, and maximum elevation in 120 seconds or less. Times of less than 60 seconds are achievable.

Tip over safety factor	Aerial ladders are required by NFPA 1901 (2003 ed.) to have a 1.5:1 “tip over” safety factor. This means the device will accommodate 1.5 times its rated capacity at every position with out tipping over. The requirement is decreased to a 1.33:1 factor while on a slope of 5 degrees. Some manufacturers rate their tip over safety at 1.5 even on the 5% slope.
Grease free design	. Some manufacturers are moving toward aerials that require no lubrication. Rather than sections of the ladder sliding along greased wear pads, they instead roll on roller system or wear pad made of metal or nylon. Greaseless systems decrease maintenance cost and time as well as offer a generally smother extension/retraction of the device.
Ladder assembly weight	Various ladder designs result in different overall ladder weight. Limiting the weight of the ladder on top of the apparatus may limit the wear and tear on the chassis caused by this ladder forces pounding the chassis as it drives the road.
Torque box construction	The “torque box” is the portion of the aerial that takes the apparatus that carries the load of the ladder. The jack system is attached to this box, as is the ladder. The box functions to keep the rig from twisting and bending as you operate the aerial. Manufacturers offer torque boxes that are bolted to the frame of the truck, an integral part of the frame, or welded to the chassis rail system.

Smoothness of operation	Various manufacturers have different features they use to increase the smoothness of operation of the aerial device. Some use rollers rather than wear pads for the ladder to slide on, one uses dual turntable motors to limit back lash, while others depend on hydraulic system design to limit the back lash or uneven movement of the ladder.
Ladder warranty	Aerial manufacturers offer a variety of warranties on their products. Most ladders come with 10 to 20 year structural warranties.
Corrosion resistance	Steel rusts, aluminum oxidizes. In order to reduce corrosion, manufacturers of steel ladders must coat and protect their ladder assemblies. Manufacturers use various processes to accomplish this. Aluminum ladders do not rust or corrode to the extent steel ladders do but do oxidize.
Turntable access	The ability to ascend to the turntable from the ground and to safely step on to the turntable from the access point is important to operations. Grab rails, climbing angles, and access to the turntable are issues that need to be examined.
Below grade operation	To what extent can the ladder be deployed below grade to assist with special rescue operations. There are varying degrees of capability amongst the manufacturers.
Load distribution charts	Although tip loads are stated in increments of 250 lbs, a ladder rated at 500 lbs tip load may be able to sustain additional loading

	while tip loaded. Some manufacturers indicate that information on the base of the ladder near the pedestal operator.
Ladder rescue attachments	Many manufacturers sell attachments points for rescue equipment or rescue attachments designed to be placed on the ladder.
Ladder lift capability	At least one manufacturer believes you should be able to use the ladder as a crane and offers an automated load management system that will allow the ladder to function as a crane within predefined limits.
Ladder waterway outlet	Manufacturers offer gated waterway outlets so that lines may be extended from the tip of the ladder.
Outrigger deployment speed	The speed of outrigger deployment varies from manufacturer to manufacturer, but all must be able to fully deploy their systems within the 90 seconds per NFPA 1901 (2003 ed.).
Outrigger pins	Some outrigger designs require that safety pins be inserted into the outriggers during set up. This requires the operator to go around the apparatus and pin each outrigger before operation.
Outrigger spread	Manufacturers have various engineering designs that provide stability to the aerial. Some outrigger systems have widths that span 18’ or better when fully extended. Others have jack spreads as small as 12’ fully spread.
Short jack capability	Some manufacturers allow the ladder to be operated without all the out riggers being fully extended. Interlocks are installed to

	keep users from operating outside of the area where it can be safely operated.
Load sensing	One manufacturer uses an automatic load sensing system that will allow use on the short jack side as long as it is in with safe parameters as sensed by the load sensing system
Capability on uneven slopes	Outrigger systems are capable of operating on various degrees of slope.

Table C6

Evaluation Scale for Determining Important Design & Construction Features

Abbreviation	*Definition*
HI	HIGH importance: Items that will critically affect the performance of the apparatus at Miami Township Division of Fire and EMS.
MOD	MODERATE importance: Items that will not critically affect the performance of the apparatus but may have a significant affect on the performance of the apparatus at Miami Township Division of Fire and EMS.
LO	LOW importance: Items that will minimally affect the overall performance of the apparatus in Miami Township Division of Fire and EMS. These items may be considered niceties or be used only in extremely rare instances.
NO	NO importance: Items that simply will not affect the overall performance of the apparatus in Miami Township Division of Fire and EMS.

Table C7

Importance of Identified Design and Construction Features

Feature	HI	MOD	LO	NO
Power Plant & Drive Train				
Engine size	9	2	0	0
Power steering type & manufacturer	9	3	0	0
Multiplexing	0	6	5	0
Rear disc brakes	7	3	1	0
Overall chassis weight	3	7	1	0
Overall travel height	7	4	0	0
Departure angle	2	8	1	0
Overall maneuverability (cramp angle, turn radius, wheele base)	8	3		
Chassis				
Cab ingress/egress ergonomics	5	6	0	0
Cab crew space	5	5	1	0
Compartment space & configuration	8	3	0	0
Hose load capacity	8	3	0	0
Hose laoding without raising the aerial	1	2	5	3
Water tank capacity	2	8	1	0
Preconnected hose lines	4	5	0	1
Other				
Single source provider	3	3	4	0

Feature	HI	MOD	LO	NO
Pump				
Pump capacity	3	7	1	0
Pump panel layout	3	6	2	0
Stainless steel plumbing	2	2	7	0
Manufacturer	0	5	4	1
Safety				
Crash testing	3	6	2	0
Side curtain air bags	2	6	3	0
Ladder				
Platform	1	3	6	1
Mount location	4	6	1	0
Ladder reach	8	2	0	0
Ladder composition	1	5	4	1
Ladder construction stock shape	0	1	9	1
Ladder tip load	6	5	0	0
Ladder tip load safety factor	5	4	2	0
Ladder environmental evaluation	2	5	4	0
Ladder tip controls	0	3	7	1
Ladder climbing width	1	5	4	1
Ladder rail height	1	5	4	1
Ladder rungs	0	2	7	2
Ladder deflection when loaded	0	2	8	1

Feature	HI	MOD	LO	NO
Ladder continued				
Deployment speed	4	6	1	0
Tip over safety factor	5	5	1	0
Grease free ladder design	2	4	4	1
Ladder assembly weight	3	5	3	0
Torque box construction	2	7	2	0
Smoothness of ladder operation	4	7	0	0
Ladder warranty	7	3	1	0
Corrosion resistance	5	6	0	0
Turntable access	6	3	2	0
Below grade operation	3	3	5	0
Load distribution charts	2	6	2	0
Ladder rescue attachments	0	6	2	3
Ladder lift capability	1	2	3	5
Ladder waterway outlet	2	2	6	1
Outrigger deployment speed	4	7	0	0
Outrigger pins	0	1	9	1
Outrigger spread	3	6	2	0
Short jack capability	1	4	6	0
Load sensing	3	5	2	1
Outrigger capability on uneven slopes	5	6	0	0

Note. The values represent the number of respondents indicating high (HI), moderate (MOD), low (LO), or no (NO) priority consideration should be given to the feature when purchasing a new apparatus.